Macropaleontology of Eocene marine rocks, upper Sespe Creek area, Ventura County, southern California

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ABSTRACT

Macrofossils identifiable to species or subspecies are tabulated and illustrated for the first time for the Matilija Sandstone (upper part), Cozy Dell Shale, and Coldwater Sandstone in the upper Sespe Creek area, Ventura County, southern California. The collections used were mostly from previous workers. Matilija Sandstone macrofossils are sparse and preserved as molds. They are shallow-marine gastropods (e.g., *Turritella uvasana uvasana*) and bivalves transported by turbidity currents into deeper waters. Cozy Dell Shale macrofossils are moderately sparse and also preserved as molds. Species in siltstone/mudstone are in situ and form moderately shallow-marine communities dominated by either starfish (e.g., *Astropecten matilijaensis*), brittle stars, or the mud-pecten bivalve *Delectopecten*. Locally, raninid crabs and the ichnofossil *Gyrolithes* are present. Species in the informal Circle B sandstone member in the middle of the Cozy Dell Shale are a few shallow-marine bivalves and scaphopods transported into deeper waters. Coldwater Sandstone macrofossils are locally common, and most have been transported and concentrated by nearshore processes. At a few localities, some fossils are in situ and form a community dominated by the gastropod *Turritella uvasana uvasana* and the bivalves *Venericardia* (*Pacificor*) *clarki clarki*, "*Crassatella*" *collina*, *Striostrea*? *tayloriana*, and *Isognomon* (*Isognomon*) *clarki*. At one locality, there is a community dominated by the spatangoid echinoid *Schizaster diabloensis* and nuculanid bivalves.

All of the macrofossils used in this study are indicative of the macroinvertebrate "Tejon Stage." The upper Matilija Sandstone, Cozy Dell Shale, and Coldwater Sandstone in the study area are assigned to the middle Eocene part of this stage on the basis of the latest medial Eocene-age constraint of the rodent-bearing basal part of the nonmarine Sespe Formation that interfingers with the Coldwater Sandstone. The geologic ranges of four species can now be extended upward into the "Tejon Stage." They are the gastropod *Xenophora stocki*, the bivalve *Glyptoactis* (*Claibornicardia*) *sandiegoensis*, the crab *Glyphithyreus weaveri*, and the spatangoid echinoid *Schizaster diabloensis*.

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INTRODUCTION

The purpose of this report is to summarize the macropaleontology of three Eocene formations in the upper Sespe Creek area, Ventura County, southern California (Fig. 1). The formations, in ascending stratigraphic order, are the upper part of the Matilija Sandstone, the Cozy Dell Shale, and the Coldwater Sandstone (Fig. 2). The study area covered in this report consists of "Area A" and a much smaller "Area B," approximately 12 km to the west (Fig. 1). Nearly all the fossil species studied in this report are from "Area A." The studied rocks are exposed in three discontinuous outcrop belts, and each outcrop belt is fault bounded (Dibblee, 1985, 1987). It is important to mention that most of the detailed geologic studies dealing with lithology, sedimentology, micropaleontology, and geochronology of the Matilija Sandstone, Cozy Dell Shale, and Coldwater Sandstone have been done south of the Santa Ynez fault. This report, therefore, is useful because it deals with these stratigraphic units north of the Santa Ynez fault.

This report is the first published study to focus on the macropaleontology of the Cozy Dell Shale and Coldwater Sandstone anywhere in the Transverse Ranges of southern California. This report also provides the first photographic documentation of species detected in these two formations.

Abbreviations for catalog and/or locality numbers are: CIT, California Institute of Technology; CSUN, California State University, Northridge; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCLA, University of California, Los Angeles; UCMP, University of California, Museum of Paleontology (Berkeley). The CIT and UCLA collections are now housed at LACMIP, and the original UCLA macrofossil locality numbers have been changed to LACMIP locality numbers by adding 20,000 to the original UCLA locality number (e.g., UCLA locality 3723 is now known as 23723). The figured specimens shown in this report are deposited at LACMIP.

PREVIOUS MACROPALEONTOLOGIC WORK IN STUDY AREA

Previous macropaleontologic investigations of marine

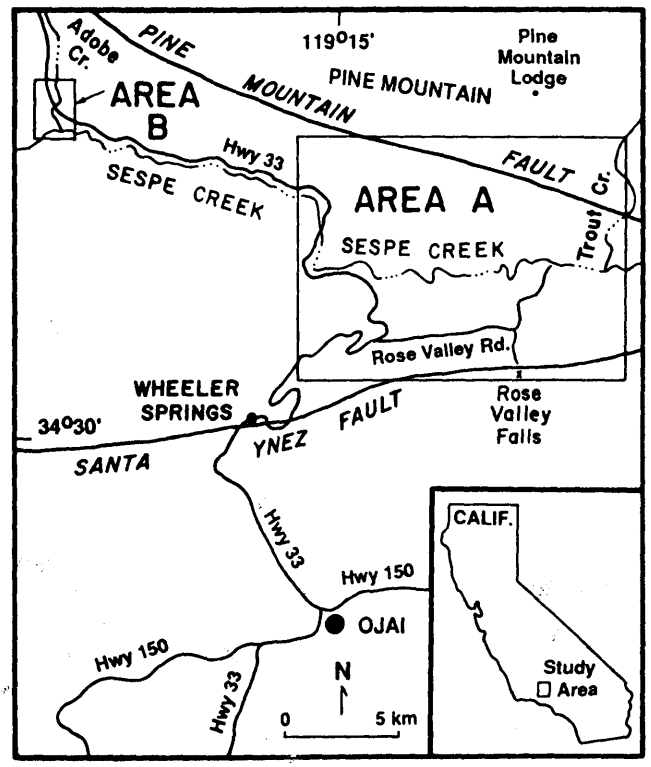


Figure 1. Index map of upper Sespe Creek area showing areas used as fossil localities in Figure 3.

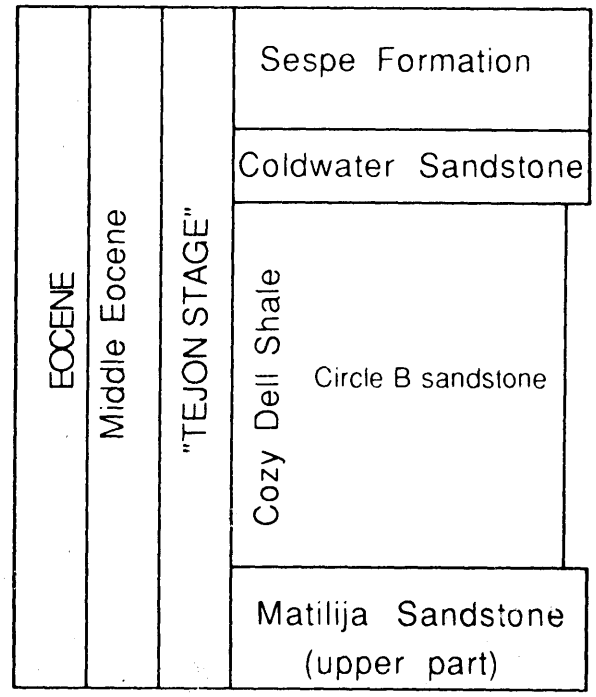


Figure 2. Generalized stratigraphy of Eocene rocks exposed in the upper Sespe Creek area.

Eocene rocks in the study area are almost all unpublished thesis or dissertation work. Dreyer (1935) mapped the western and central parts of the study area and listed macrofossils from the Matilija Sandstone (his unit 3) and the Coldwater Sandstone (his unit 5). He did not show any macrofossil localities on his geologic map. He also did not provide any locality information, even though UCLA records show that he had a few localities. Dreyer (1936) also briefly summarized the geology of the study area.

Badger (1957) mapped the geology of the central and southern parts of the study area (including post-Eocene rocks) and made collections of macrofossils from the Matilija Sandstone (his Tcdl unit), the Cozy Dell Shale, and the Coldwater Sandstone. He provided checklists and plotted his localities. All of the listed taxa are now in the LACMIP collection.

Jestes (1963) did a regional stratigraphic study of some Eocene rocks, and one of his areas included the upper Sespe Creek area. He made a macrofossil collection from one locality (loc. LAMCIP 24260) in the Matilija Sandstone (his Derrydale sandstone) in the upper Sespe Creek area. He gave a macrofaunal list and provided locality information. All of the listed taxa are now in the LACMIP collection.

Fossils collected at locality LACMIP 10571 (from float material derived from the Cozy Dell Shale) by John Alderson, a private collector, are also in the LACMIP collection.

Shmitka (1970) mapped the geology of the southeastern part of the study area. He listed a few mollusks from the Cozy Dell Shale and from the Coldwater Sandstone. He did not indicate whether or not the specimens were deposited at a museum.

Jaio (1989) did a sedimentologic study of the Coldwater Sandstone in the entire study area and made limited collections of macrofossils. He gave a macrofaunal checklist and plotted his 41 localities. Specimens from only 14 of these localities, however, were deposited in the CSUN collection. Specimens from his other localities could not be found.

Since the late 1960's, several advanced geologic mapping classes from California State University, Northridge, have used the upper Sespe Creek area as a field area and limited collections of Eocene macrofossils were made. Also in 1977, in the capacity as a field-class instructor, the author collected some Eocene macrofossils from the Circle B sandstone.

The only published works that deal with marine Eocene macrofossils from the study area are limited to the analysis of only a few species. Durham and Roberts (1948) described and named two new species of starfish from a locality in the Cozy Dell Shale (their upper Cretaceous "Chico Formation") in the extreme southwest corner of the study area. This locality is LACMIP 7223, which is the same as locality CIT 1679 of Durham and Roberts (1948).

Verastegui (1953) described and named the bivalve *Venericardia* (*Leuroactis*) *popenoei* based on a single specimen (holotype, UCLA 15689) presumably collected by Dreyer (1935) from locality LACMIP 20581 [= loc. UCLA 581], in the Coldwater Sandstone in the central part of the study area. This specimen is anomalous because it is the only one like it found in the Coldwater Sandstone in the study area. Every other venericardid specimen found in the area belongs to *V.*

(*Pacificor*) *clarki clarki*. It is possible that Verastegui mixed up his localities and that his *V.* (*L.*) *popenoei* is from another formation in another area.

Squires (1989) mentioned the presence of the bivalve *Isognomon* (*I.*) *clarki* from locality CSUN 252 in the central part of the study area.

Stock (1938) and Lindsay (1968) reported land-mammal fossils from the Sespe Formation in the vicinity of the Hartman Ranch in the western central part of the study area. Kelly (1990) summarized and refined the biostratigraphic constraints.

METHODS

Nearly all the macrofossils collected by previous workers in the study area are now stored at either LACMIP or CSUN, and all of these fossils were examined by the author. Many of these fossils had been assigned to various taxonomic levels by previous workers. For the purpose of this report, all the specimens were reidentified and carefully checked by comparison with published descriptions and illustrations, as well as by comparison with selected type and non-type specimens deposited at LACMIP and CSUN. Many of the identifications made by previous workers could not be verified. In most cases, the reason was because of poor preservation. In other cases, the specimens had been misidentified.

Specimens that could be identified with certainty to the species or subspecies level represent the focus of this present report. These taxa are listed in Tables 1 to 4 and are illustrated in Plates 1 to 3. Many specimens were poorly preserved and could only be identified as to family. Nearly all of these poorly preserved specimens are mentioned only in the text and are not illustrated. Exceptions are a palinurid? (spiny lobster) and an ophiuroid (brittle star) from the Cozy Dell Shale mudstone/siltstone. These two fossils are listed in Table 2 and illustrated in Plate 1. Their rarity in the fossil record of lower Tertiary rocks of the Pacific coast of North America warrants their illustration.

A total of 38 localities (Fig. 3) were used in constructing Tables 1 to 4. Two of the localities are from the upper part of the Matilija Sandstone, 5 are from the Cozy Dell Shale mudstone/siltstone, 7 are from the informal Circle B sandstone member of the Cozy Dell Shale, and 24 are from the Coldwater Sandstone. Of the 38 localities, 21 are from Badger (1957), 9 are from CSUN field-mapping classes or senior-thesis projects, 4 are from Jaio (1989), 3 are from the LACMIP, and 1 is from Jestes (1963).

The molluscan stages used in this report stem from Clark and Vokes (1936) who proposed five molluscan-based provinicial Eocene stages; namely, "Meganos," "Capay," "Domengine," "Transition," and "Tejon." The stage names are in quotes because they are informal. Givens (1974) modified the use of the "Capay Stage." It is in this modified sense that "Capay Stage" is used herein. Saul (1983, fig. 1) and Squires (1988, fig. 1) correlated the stages to the calcareous nannofossil zonation of Okada and Bukry (1980) and to the standard planktonic foraminifera zones.

STRATIGRAPHIC UNITS

Matilija Sandstone

Regional Characteristics. The Matilija Sandstone is a major stratigraphic unit in the western part of the Transverse Ranges. The formation has been mapped in a fairly continuous outcrop pattern extending from Fillmore (Merrill, 1954; Dibblee, 1990) westward to the Point Conception area (Kleinpell and Weaver, 1963), a distance of 120 km. The formation may be present an additional 24 km to the northeast of Fillmore in the Whitaker Peak area near Lake Piru (Squires, 1987; Yamashiro, 1989).

The Matilija Sandstone was named by Kerr and Schenck (1928), and the type section is at Matilija Hot Springs a few kilometers northwest of Ojai (Vedder, 1972, fig. 3C). At its type locality, the formation has it maximum thickness of 800 m and is transitional with both the underlying Juncal Formation and the overlying Cozy Dell Shale. The Matilija Sandstone forms prominent strike ridges that consist mostly of sandstone with some siltstone. At the type locality, in the upper part of the formation, there are also thin beds of mudcrack-bearing siltstone with abundant brackish-marine mollusks and thin beds of limestone and gypsum (Link and Welton, 1982; Squires, 1991). The Matilija Sandstone mostly represents a shallowing sequence from bathyal-depth submarine-fan turbidites in the lower part of the formation to neritic and, locally, brackish-marine to nonmarine conditions in the upper part of the formation. The uppermost part of the formation represents a deepening sequence that continues into the overlying Cozy Dell Shale (Link and Welton, 1982). Macrofossils are rare in the turbidites, but at the type section there are coquinas of mollusks in the brackish-marine deposits (Jestes, 1963; Squires, 1991). These mollusks indicate assignment to the "Tejon Stage" (middle middle to upper Eocene). Based on the presence of planktonic foraminifers and calcareous nannofossils in the overlying Cozy Dell Shale, Link and Welton (1982) assigned the Matilija Sandstone in the vicinity of the type section to the middle Eocene P11 and P12 Zones (equivalent in part to the "Tejon Stage").

Givens (1974) did a detailed biostratigraphic analysis of mollusks from the Matilija Sandstone in the Pine Mountain area, northeast of the study area. He assigned the mollusks to the "Tejon Stage."

Study Area Characteristics. Only the upper part of the Matilija Sandstone crops out in the study area, but the formation is 460 m thick in this area (Fritsche and Shmitka, 1978). The formation is transitional with the overlying Cozy Dell Shale. The upper Matilija Sandstone crops out in the cores of two anticlines in the southern part of "Area A." One anticline intersects Highway 33 about 2 km (distance along the highway) north of the turnoff to Rose Valley. The other anticline is in Lion Canyon, just south of Lion Campground. In both places, the formation consists of very fine-grained sandstone with minor interbeds of siltstone. In Lion Canyon, turbidite-related Bouma sequences are prevalent.

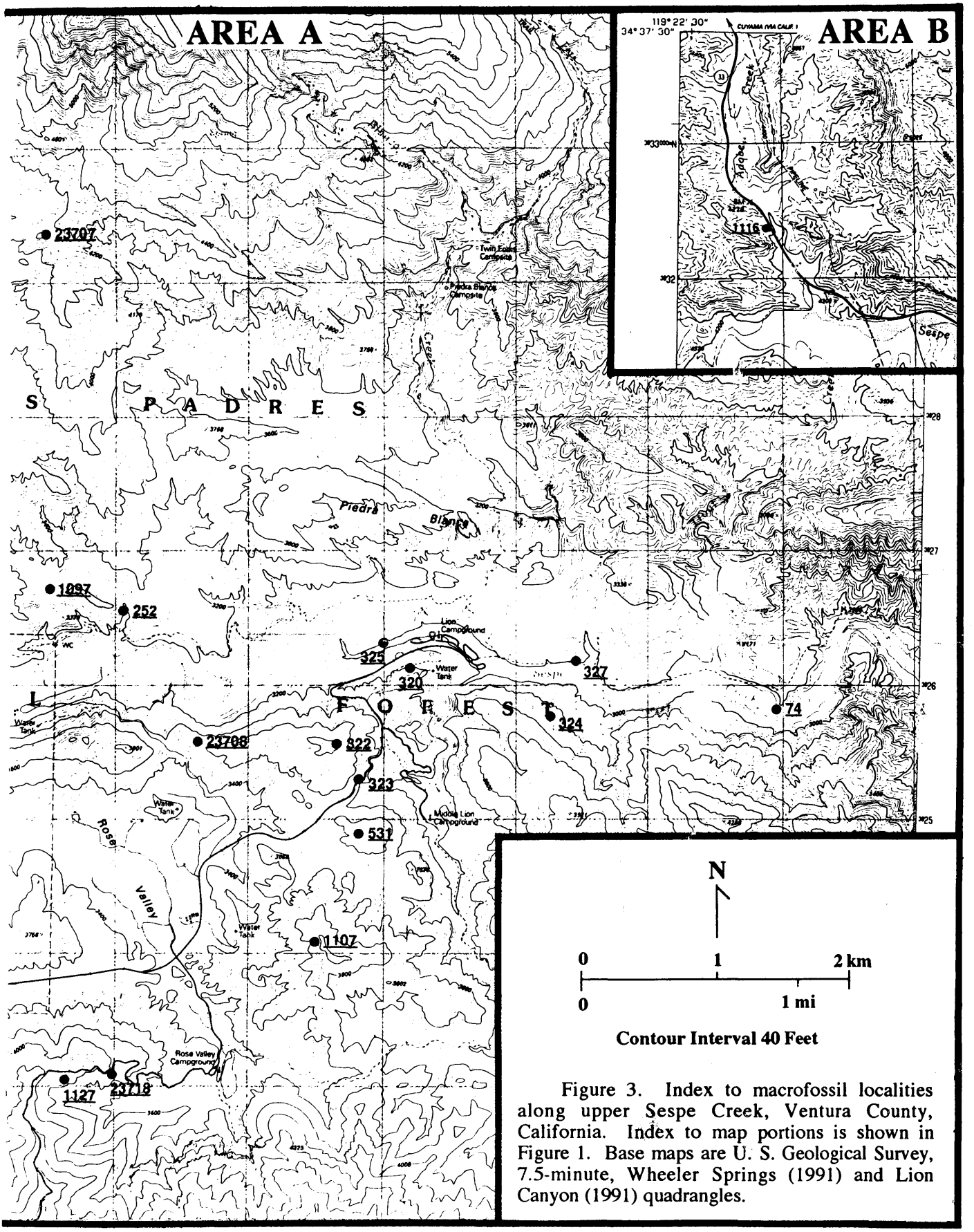
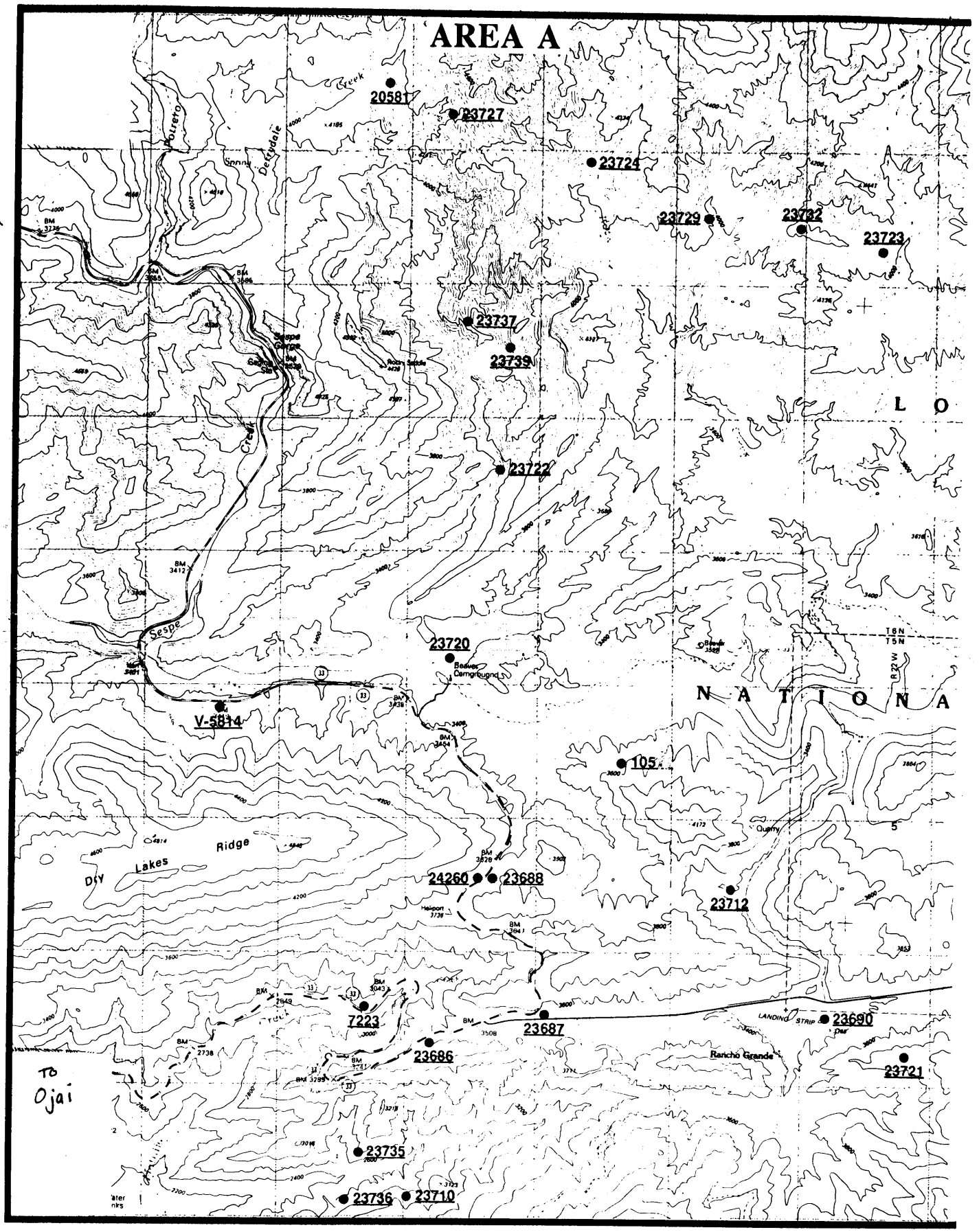


Figure 3. Index to macrofossil localities along upper Sespe Creek, Ventura County, California. Index to map portions is shown in Figure 1. Base maps are U. S. Geological Survey, 7.5-minute, Wheeler Springs (1991) and Lion Canyon (1991) quadrangles.


AREA A
20581
23727
23724
23729
23732
23723
23737
23739
23722
23720
V-5814
105
24260
23688
23712
7223
23687
23690
23686
23721
23735
23736
23710
Sespe Creek
Dry Lakes Ridge
Rancho Grande
LANDING STRIP
Beaver Campground
T8N
T5N
R22W
TO Ojai
TO Cuyama Valley

Study Area Macrofossils. Macrofossils are very rare in the upper Matilija Sandstone and were found at only two localities. The fossils are almost always preserved as molds. Only four gastropods and three bivalves were identifiable (Table 1, Pl. 1). Other taxa too poorly preserved for generic identification are a scaphopod, a few gastropods (naticid, nassariid, turrid), and some bivalves (glycymerid, lucinid, crassatellid, pitarid, solenid, tellinid).

TABLE 1. CHECK LIST OF UPPER SESPE CREEK, UPPER MATILIJA SANDSTONE MACROFOSSILS IDENTIFIABLE TO SPECIES/SUBSPECIES

TAXA	LACMIP LOCS.	
	23688	24260
GASTROPODA		
Turritella uvasana uvasana Conrad	x	x
Architectonica (A.) hornii Gabb	x	
Calyptraea diegoana (Conrad)	x	x
Calorebama inornata (Dickerson)		x
BIVALVIA		
Brachidontes (B.) cowlitzensis (Weav. & Pal.)		x
Acanthocardia (Shedocardia) brewerii (Gabb)	x	
Tellina lebecki Anderson & Hanna	x	

Both of the upper Matilija Sandstone localities are along Highway 33 a short distance north of the turnoff to Rose Valley. One of the localities (LACMIP 23688) was found by Badger (1957), and the other locality (LACMIP 24260) was found by Jestes (1963) who placed it in his informal Derrydale sandstone. His "type section" of this sandstone is in Derrydale Creek just north of Sespe Gorge. Vedder and others (1973) and Dibblee (1985) mapped the "type section" rocks of the Derrydale sandstone as the Matilija Sandstone. Attempts by the author to find localities LACMIP 23688 and 24260 were unsuccessful.. The exposures in the vicinity of these two localities are barren of macrofossils. The exposures consist of hard, fine-grained sandstone in 1 to 1.5-m-thick beds separated by thin partings of dark brown siltstone or mudstone. There are small-scale crossbeds, and some of the beds show parallel laminae.

Several large slabs of rock and numerous hand specimens from both localities are in the LACMIP collection. It was necessary for the early collectors to take rock matrix because preservation is entirely as molds. Rubber casts were made by them in order to identify the specimens. The rock slabs and hand specimens show that the shells were concentrated together in coquinas. They are a mixture of small fragments of mollusks and nearly complete, large specimens of *Turritella uvasana uvasana* up to 9 cm long. Jestes (1963, p. 134) reported that the shells at locality 24260 were concentrated by currents into depressions or erosional channels (no larger than 20 cm thick and 60 cm wide) on the sea floor. He concluded that the distance of post-mortem transport was not great and that strong wave action was not involved because of the presence of unbroken minute spires of turritellids in the matrix and unworn delicate sculpture on some of the bivalves. He noted also that one specimen of the bivalve *Acanthocardia* (*Schedocardia*) *brewerii* showed molds of small, delicate spines. The author agrees with Jestes' taphonomic observations and also found unworn spiral ribs on all specimens of *Turritella uvasana uvasana*. A few of these turritellids approach *T. u. neopleura* in morphology.

The macrofossils found in the upper Matilija Sandstone in the study area are also found in shallow-marine (neritic) deposits of Eocene age elsewhere on the Pacific coast of North America (Givens, 1974; Squires, 1984). The study area specimens, however, underwent post-mortem transport from neritic depths into deeper waters. Transport was most likely by means of turbidity currents, which would tend to minimize abrasion and preserve delicate shell sculpture.

The macrofossils found in the upper Matilija Sandstone in the study area indicate assignment to the "Tejon Stage" (Fig. 2). *Architectonica* (*A.*) *hornii* and *Tellina lebecki* are known only from this stage (Givens, 1974). The "Tejon Stage" spans from medial medial through late Eocene, but the upper Matilija Sandstone in the study area is assignable to the middle Eocene part of the "Tejon Stage." This determination is based on the latest medial Eocene age constraint of the Sespe Formation that overlies the Coldwater Sandstone in the study area.

Cozy Dell Shale

Regional Characteristics. The Cozy Dell Shale is a major stratigraphic unit in the western part of the Transverse Ranges. The formation has been mapped in a fairly continuous outcrop pattern extending from the Fillmore area (Merrill, 1954; Dibblee, 1990) westward to the Point Conception area (Kleinpell and Weaver, 1963), a distance of 120 km.

The Cozy Dell Shale was named by Kerr and Schenck (1928), and the type section is in a tributary to the Ventura River a few kilometers north of Ojai (Vedder, 1972, fig. 3C). At its type locality, the formation has a thickness of 760 m and is transitional with both the underlying Matilija Sandstone and the overlying Coldwater Formation. The Cozy Dell Shale is a non-resistant unit that consists mostly of siltstone with some interbedded sandstone. The Cozy Dell Shale mostly represents a rapid deepening sequence that resulted in the accumulation of bathyal-depth basin-plain and slope deposits interbedded with some turbidites. The uppermost part of the formation represents a shallowing sequence that continues into the overlying Coldwater Sandstone (Link and Welton, 1982). Macrofossils are uncommon in the Cozy Dell Shale, but locally there can be plant remains and some starfish and ophiuroids (brittle stars) (Durham and Roberts, 1948) and mollusks (Vedder and others, 1973). Based on the presence of benthic foraminifers, Dibblee (1966) assigned the Cozy Dell Shale to the A-1 and possibly A-2 Zones of Laiming (1939). Almgren and others (1988) emended Laiming's zones, and Zones A-1 and A-2 are correlative to the middle through lower upper Eocene. On the basis of planktonic foraminifers and calcareous nannofossils, Link and Welton (1982) assigned the Cozy Dell Shale to the middle Eocene P11 and P12 Zones (equivalent in part to the Tejon Stage").

Study Area Characteristics. The formation can be as much as approximately 1,000 m thick in the study area (Fritsche and Shmitka, 1978) and is transitional with both the underlying Matilija Sandstone and the overlying Coldwater Sandstone. The Cozy Dell Shale crops out throughout the southern part of "Area A," in "Area B," and also along Highway 33 between the two areas. Most outcrops consist of mudstone or siltstone, and spheroidal weathering is common.

Slatt and Thompson (1985) studied the sedimentology and micropaleontology of outcrops of the Cozy Dell Formation along Highway 33 in the extreme southwestern part of the study area. They reported that the formation in this area was deposited in a low-gradient, gullied upper slope environment (150 to 500 m depths) that may be analogous to that of the modern Mississippi River delta front. They reported that the formation in this area is assignable to the middle Eocene P11 and P12 Zones, based on the presence of planktonic foraminifers. During this present investigation, four microfossil samples were collected from the upper part of the Cozy Dell Shale from widely scattered localities throughout the entire study area. All the samples were barren.

Fritsche (this volume) interpreted that the Cozy Dell Shale along upper Sespe Creek is mainly a regressive sequence of slope and shelf mudstone deposits.

In the southern and west central parts of "Area A," there is a well sorted sandstone unit in the middle of the Cozy Dell Shale. This sandstone unit has been informally referred to by Jestes (1963) and Fritsche and Shmitka (1978) as the Circle B sandstone member of the Cozy Dell Shale. Dibblee (1987) mapped this sandstone unit as part of the Coldwater Sandstone, and he mapped the mudstone and siltstone that immediately overlie the Circle B sandstone as a finer grained unit (his Tcwsh unit) within the Coldwater Sandstone. Fritsche (this volume) mapped the sandstone unit as sandstone lenses in the Cozy Dell Shale and interpreted that the lenses were deposited as sand lobes on top of and adjacent to the dominant shelf and slope mud of the Cozy Dell Shale.

Study Area Macrofossils of the Cozy Dell Shale (excluding the Circle B sandstone member). Macrofossils are sparse in the the Cozy Dell Shale mudstone/siltstone, and specimens were found only at five localities in the southern part of "Area A". The fossils are preserved as molds. Only five species were identifiable. These are one bivalve, two crabs, and two starfish, and they are listed in Table 1 and illustrated in Plate 1. Because of their rarity as Eocene fossils in California, a palinurid? (spiny lobster) and an ophiuroid, are also listed and illustrated. Because of its importance as a paleoenvironmental indicator, *Delectopecten* sp. indet. is included in Table 2 and Plate 1. Other taxa too poorly preserved for generic identification are carbonized plant remains, some gastropods (turritellid, naticid, two turrids), and fish scales.

Localities LACMIP 7223 and 10571 are very exceptional because of their richness of starfish and brittle stars. These types of macroinvertebrates are rare in the fossil record. At locality 7223, Durham and Roberts (1948) found 30 specimens of starfish, and inspection by the author of the micaceous, very sandy siltstone from this locality also revealed a few complete brittle stars. Many of the starfish specimens are complete. Most specimens have the arms fully extended, but a few have them bent back on themselves. Some even possess their delicate marginal spines on their arms. Most starfish taxa are epifaunal and must be buried quickly and have limited or no physical and biological reworking in order to be preserved (Blake and Zinsmeister, 1988). Rapid burial is indicated for the Cozy Dell Shale specimens because they are complete and the arms are straightly extended. Other supporting data are, as Durham and Roberts (1948) noted, the specimens show no alignment of any sort and approximately the same number of individuals are right side up as are overturned.

Durham and Roberts (1948) mentioned that many fragments of leaves and pockets of carbonized plant material were found both above and below the single layer of *Astropecten* starfish remains at locality 7223, and they interpreted, based on the plant fragments, that the starfish probably lived in depths less than 100 m, perhaps near the low-tide mark.. Repeated attempts by the author to find this locality were unsuccessful. In recent years, there have been many landslides along the steeply dipping outcrops next to Highway 33 in the immediate vicinity of where the locality should be, and it is concluded that the locality has been destroyed by highway crews cleaning up the area.

Astropecten is an extant genus, and two species live off the coast of California on soft bottoms. *Astropecten armatus* is common in depths to 60 m (Morris and others, 1980), and *A. verilli* is most abundant at depths around 90 m but can be found to 205 m (Thompson and others, 1993). *Astropecten* at locality 7223, therefore, indicates a depth of about 60 to 200 m. Complete specimens of *Astropecten* were also found at locality 10571, where they are associated with deep-water "mud pectens" (discussed below).

In the micaceous, sandy siltstone at locality 10571, there are numerous complete brittle stars with their long, delicate arms completely intact. Some specimens have their delicate marginal spines on the arms. One of the collected slabs of rock measures 14 cm by 14 cm and contains (on a single bedding plane) 14 brittle stars, three small starfish (*Astropecten matilijaensis*), numerous small pieces of carbonized plant remains, and a few fish scales. The brittle stars show a partial growth series, with disk diameters ranging from 6 to 14 mm. Another slab, 8.5 cm by 11 cm, has 9 brittle stars and a starfish. In some of the other hand specimens of rock, there are "mud pectens," and raninid crabs. The "mud pecten" specimens are delicate, single valves. The crab carapaces have retained their delicate anterolateral spines, and one specimen has its legs. A few turrid gastropods were also found, and they have their long, fragile anterior canals intact. There are small pieces of carbonized plants in every hand specimen of rock from this locality. Material from locality 10571 was found in float, but it was derived from the Cozy Dell Shale. This conclusion is based on the co-occurrence of the starfish *Astropecten*

TABLE 2. CHECK LIST OF UPPER SESPE CREEK, COZY DELL SHALE MUDSTONE/SILTSTONE MACROFOSSILS

TAXA	LACMIP LOCALITIES				
	7223	10571	23686	23690	23712
BIVALVIA					
Propeamussium interradiatum (Gabb)			x		
Delectopecten sp. indet.		x		x	
PALINURA (spiny lobster)					
palinurid?					x
BRACHYURA (crab)					
Raninoides washburnei? Rathbun		x			
Glyphithyreus weaveri (Rathbun)		x			
ASTEROIDEA (starfish)					
Astropecten matilijaensis Durham & Roberts	x	x			
Henricia (?) venturana Durham & Roberts	x				
OPHIUROIDEA (brittle star)					
ophiuroid	x	x			

matilijaensis and the brittle stars at localities 10571 and 7223. The latter locality is definitely known to be from the Cozy Dell Shale.

At the other localities in the mudstone/siltstone of the Cozy Dell Shale, only a few delicate single valves of "mud pectens" were found. These "mud pectens" are small epifaunal specimens of *Propeamussium interradiatum* and *Delectopecten* sp. indet. Hickman (1984) established that "mud pectens" represent one of the more common indicators of Cenozoic and modern deep-water siltstone/claystone deposits along the eastern Pacific margin, and Hickman and Nesbitt (1980) described a modern low-diversity "mud-pecten" community from the Gulf of Alaska in waters consistently below 200 m.

Squires and others (1992) reported a "mud-pecten" community in micaceous siltstone and with abundant plant fragments and some fish scales, just like that found in the Cozy Dell Shale, in bathyal deposits of the middle Eocene Aldwell(?) Formation, eastern Olympic Peninsula, Washington.

On the basis of the presence of delicate morphologic parts on specimens at all of the macrofossil localities of the Cozy Dell Shale mudstone/siltstone, it is concluded that the macroinvertebrates are in situ and represent offshore (below maximum storm base) communities. The small pieces of plants and the fish scales settled out of suspension.

Several specimens of the raninid crab *Raninoides washburnei*? were found at locality 10571. Preservation does not allow positive specific identification. If the specimens are *R. washburnei*, they would be the first occurrence of this species in California. Previously, the species has been recorded only from middle Eocene to upper Oligocene strata in Oregon (Rathbun, 1926).

A few specimens of the ichnofossil *Gyrolithes* were found in float from the Cozy Dell Shale mudstone/siltstone in the Rose Valley area. *Gyrolithes* is a dwelling burrow that is loosely coiled with its coil axis vertical. According to Boyer and Warme (1987), *Gyrolithes* is probably the result of the activity of a decapod crustacean. They reported that *Gyrolithes* is characteristic of muddy substrates affected only by low-current velocities, and they found the ichnofossil to be common in brackish-marine, quiet-water lagoon deposits of the Eocene Delmar Formation, San Diego County, southern California. There is no evidence of any brackish-marine macrofauna in the Cozy Dell, but the presence of *Gyrolithes* does further reinforce the interpretation that the Cozy Dell macrofauna lived in ocean waters largely unaffected by storms.

Macrofossils of the Circle B sandstone member. Macrofossils are sparse in the informal Circle B sandstone member of the Cozy Dell Shale, and specimens were found at eight localities. The fossils are preserved as molds. Only five species were identifiable (Table 3, Pl. 2). These are one scaphopod, one gastropod, and three bivalves. Other taxa too poorly preserved for generic identification are a glycymerid bivalve and a solenid bivalve.

The few scaphopods found are complete and show fine spiral ribbing. The few bivalves found are unbroken single valves that also show fine spiral ribbing. The disarticulated condition of the bivalves indicates some post-mortem transport.

Macrofossils most commonly found in the Circle B sandstone are the bivalve *Callista andersoni* and the scaphopod *Dentalium stentor*. The bivalve is found in shallow-marine (neritic) deposits of the Matilija Sandstone in the Pine Mountain area (Givens, 1974) and in nearshore-shelf deposits of the Eocene Mission Valley Formation, San Diego County (Givens and Kennedy, 1979). The scaphopod has been found in shallow-marine deposits of the Matilija Sandstone? in the Whitaker Peak area (Squires, 1987) and in the middle Eocene part of the Llajas Formation, Simi Valley (Squires, 1984). The study area specimens, however, underwent post-mortem transport from neritic depths into deeper waters. Transport was most likely by means of storm-generated mass flows that have been recognized by Fritsche (this volume) as important in the deposition of this unit as sand lobes on top and adjacent

TABLE 3. CHECK LIST OF UPPER SESPE CREEK, CIRCLE B SANDSTONE MEMBER OF THE COZY DELL SHALE MACROFOSSILS IDENTIFIABLE TO SPECIES/SUBSPECIES

TAXA	CSUN LOCALITIES					LACMIP LOCS.		(ex UCLA)
	320	322	323	324	531	23687	23708	
SCAPHOPODA								
Dentalium stentor Anderson & Hanna			x	x	x			
GASTROPODA								
Ficopsis hornii (Gabb)						x		
BIVALVIA								
Brachidontes (B.) cowlitzensis (Weaver & Palmer)	x							
Callista hornii (Gabb)		x						
Callista andersoni (Dickerson)		x					x	
		16669			16668			

to the dominant shelf and slope mud of the Cozy Dell Shale.

The most age-diagnostic macrofossils in the Cozy Dell Shale are some of its taxa in the Circle B sandstone member. *Ficopsis hornii*, *Callista andersoni*, and *Callista hornii* range from the "Transition Stage" through the "Tejon Stage" (Givens, 1974). The Cozy Dell Shale in the study area is underlain by "Tejon Stage" strata, therefore the formation is assigned to the "Tejon Stage."

The geologic range of the xanthoid crab *Glyphithyreus weaveri* can now be extended into the "Tejon Stage" on the basis of its presence in the Cozy Dell Shale mudstone/siltstone in the study area. Previously, its was known to range from the "Capay Stage" through the "Domengine Stage" (Squires, 1984).

Coldwater Sandstone

Regional Characteristics. The Coldwater Sandstone is a major stratigraphic unit in the western Transverse Ranges. The formation has been mapped in a fairly continuous outcrop pattern extending from Fillmore (Merrill, 1954; Dibblee, 1990) westward to the Santa Barbara area (Kleinpell and Weaver, 1963; Dibblee, 1966), a distance of about 80 km. West of the Santa Barbara area, the Coldwater Sandstone is known to interfinger with mudstone/siltstone in the upper part of the Sacate Formation (Weaver, 1965, fig. 1). The Sacate Formation has been mapped from the Santa Barbara area westward to the Pont Conception area (Kleinpell and Weaver, 1963; Dibblee and Weaver, 1965; Dibblee, 1966), a distance of about 40 km.

Watts (1897, 1900) was the first to call attention to an unnamed white sandstone in Coldwater Creek about 8 km north of Fillmore, Ventura County. Kew (1924) referred to these strata as the "White sandstone, locally known as 'Coldwater sandtone'." Taliaferro (1924) proposed that the strata be called the Coldwater member of the Tejon Formation, a designation used by Kerr and Schenck (1928) who mapped the same stratigraphic unit north of Ojai. Taliaferro (1924) also designated the type section as Coldwater Creek, where Watts had originally recognized the stratigraphic unit. Vedder (1972, fig. 3D) showed the location of the type section. In more recent years, the Coldwater Sandstone has been used as a formation name (e.g., Page and others., 1951; Dibblee, 1966). Some workers apply quotation marks to the name because the term has been used before in American stratigraphic literature. Vedder (1972) argued that the long local usage should justify its adoption as a formal name. At its type locality, the formation is 120 to 150 m thick and is transitional with the underlying Cozy Dell Shale. The Coldwater Sandstone therein is unconformably overlain by the Sespe Formation. Elsewhere, however, the upper contact is either a local disconformity or is gradational (Vedder, 1972). The Coldwater Sandstone consists of sandstone with minor interbeds of greenish-gray to red siltstone and represents shallow-marine to coastal-marine deposits with macrofossils abundant locally. They indicate a "Tejon Stage" age (medial medial to late Eocene). Kleinpell and Weaver (1963, fig. 5) showed the Coldwater Sandstone to be equivalent to the *Amphimorphina jenkensi* Zone of Mallory (1959). Almgren and others (1988) equated this zone to the A-1 Zone of Laiming (1939) and assigned the A-1 Zone to the uppermost middle through lower upper Eocene.

Study Area Characteristics. The Coldwater Sandstone is 75 to 150 m thick in the study area (Fritsche and Shmitka, 1978), is mostly fine- to medium-grained sandstone, contains some siltstone in the upper part, and is transitional with the underlying Cozy Dell Shale. Locally, there is interfingering between the Coldwater Sandstone and the overlying Sespe Formation, and the arbitrary contact accounts for inconsistencies in the outcrop pattern on Badger's (1957) geologic map versus that on Dibblee's (1987) geologic map. The Coldwater Sandstone is transitional with the Sespe Formation in the central and southern parts of the study area, but, in the western part, the Coldwater Sandstone unconformably underlies the Sespe Formation (Dibblee, 1985). Also, the color and gross lithologic character of the Sespe Formation in the western part of the study area are different from that of the formation elsewhere in the study area. These differences were also noted by McCracken (1969).

Jaio (1989) reported that the depositional system of the Coldwater Sandstone in the central and southern parts of the study area was a wave-dominated shoreline. He interpreted that the lower part of the formation was deposited in the shoreface and foreshore environments, the middle part in mud

flat and chenier-ridge environments, and the upper part in the foreshore and upper delta-plain environments. All the macrofossils that he found were in shell-hash beds, and he interpreted that the shells had been concentrated into lenses by means of storm activity. Jaio interpreted that the depositional system of the Coldwater Sandstone in the northwestern part of the study area (includes Area "B" on Figures 1 and 3) was a tide-dominated shoreline with intertidal mudflats and sandflats. He measured a section (his Sandstone Camp Section) that included locality CSUN 1116 and interpreted that the fossiliferous and structureless sandy siltstone was a suspension deposit in a mud-flat environment.

Study Area Macrofossils. Macrofossils are fairly common in the Coldwater Sandstone, and specimens were found at 24 localities. Most of these are in the central part of "Area A." Preservation is good to poor for most of them, and, locally, preservation can be excellent for the oyster *Striostrea? tayloriana* and the venericardid bivalve *Venericardia (Pacificor) clarki clarki*. A total of 24 taxa were collected from the Coldwater Sandstone. Nineteen taxa could be identified to species/subspecies. These are nine gastropods, nine bivalves, and one spatangoid echinoid (Table 4, Pls. 2 and 3). Other taxa too poorly preserved for generic identification are a few gastropods (naticid, ranellid, turrid) and some bivalves (nuculanid, arcid, pectinid, lucinid, pitarid, corbulid).

At most of the localities in the central and southern parts of "Area A," macrofossils were found in shell-hash beds tightly packed with jumbled and broken single valves of bivalves. These remains have undergone post-mortem transport and have been concentrated by means of currents and/or waves. The shells were locally derived because they are the same species that can be found in situ at a few localities in the Coldwater Sandstone in the study area. At locality CSUN 252, several articulated specimens of *Isognomon (I.) clarki*, *Striostrea? tayloriana*, *Callista conradiana*, and *Venericardia (Pacificor) clarki clarki* were found. The *Isognomon* and *Striostrea?* specimens are large and are up to 12 cm in height. At locality LACMIP 20581, many articulated specimens of *Striostrea? tayloriana*, *Venericardia (Pacificor) clarki clarki*, and *"Crassatella" collina* were found along with some articulated specimens of *Callista conradiana* and some large unabraded specimens, up to 7 cm height, of the gastropod *Turritella uvasana uvasana*.

At locality LACMIP 23722, many articulated specimens of *Venericardia (Pacificor) clarki clarki* and some articulated specimens of *Isognomon (I.) clarki* were found. At locality CSUN 74 and locality LACMIP 23739, several articulated specimens of *Glyptoactis (Clairbornicardia) sandiegoensis* were found.

At these above-mentioned localities where there are variously sized, articulated specimens of bivalves, the mollusks are in situ and represent communities. With respect to depth of water, the fauna of these communities indicate deposition somewhere between nearshore and the shelf break. Squires (1989), in a review of stratigraphic and geographic occurrences of *Isognomon (I.) clarki* from the Eocene of California and

TABLE 4. CHECK LIST OF UPPER SESPE CREEK, COLDWATER SANDSTONE MACROFOSSILS IDENTIFIABLE TO SPECIES/SUBSPECIES

	CSUN LOCALITIES								LACMIP LOCALITIES (ex UCLA)														
LOCALITIES (read vertically, from top to bottom):	7	2	3	3	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	4	5	2	2	0	1	1	1	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		2	5	7	9	0	1	2	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7
					7	7	6	7	8	0	1	1	2	2	2	2	2	2	3	3	3	3	3
TAXA									1	7	0	8	0	1	2	3	4	7	9	2	5	6	7	9
GASTROPODA																								
Nerita (Theliostyla) triangulata Gabb													x								x			
Turritella uvasana uvasana Conrad									x			x						x	x			x	x	x
Calyptraea diegoana (Conrad)				x							x			x								x		
Crepidula (Spirocrypta) pileum (Gabb)																x								
Xenophora stocki Dickerson																					x			
Pachycrommium clarki (Stewart)									x							x								
Polinices (Euspira) nuciformis (Gabb)									x									x						
Ficopsis hornii (Gabb)									x							x								
Calorebama volutaeformis (Gabb)											x													
BIVALVIA																								
Brachidontes (B.) cowlitzensis (Weaver & Palmer)											x					x								
Isognomon (I.) clarki (Effinger)		x										x		x	x									
Chlamys calkinsi (Arnold)	x		x	x									x	x	x						x	x		
Striostrea? tayloriana (Gabb)		x			x				x							x				x				
Venericardia (Pacificor) clarki clarki Weaver & Palmer		x							x						x	x	x			x				
Glyptoactis (Claibornicardia) sandiegoensis (Hanna)	x																							x
"Crassatella" collina Conrad									x							x		x		x				
Acanthocardia (Schedocardia) brewerii (Gabb)											x													
Callista conradiana (Gabb)		x			x		x		x	x	x	x			x	x		x						
SPATANGOIDA (heart urchins)																								
Schizaster diabloensis Kew							x																	

16671 16670 16672

Oregon, reported that most of the populations of this species are in nearshore-sandstone deposits. At the generic level, the *Turritella-Venericardia-"Crassatella"* faunal components of the study area Coldwater Sandstone communities have counterparts in the middle Eocene "Stewart bed" community described by Squires (1984) from the Llajas Formation, Simi Valley, southern California. The "Stewart bed" community lived near the shelf/slope break.

The only macrofossils found in the Coldwater Sandstone in "Area B" (Figs. 1, 3) of the study area are from locality CSUN 1116. These macrofossils are commonly occurring complete specimens of various sizes of the spatangoid echinoid *Schizaster diabloensis* and articulated specimens of a poorly preserved nuculanid bivalve species. These taxa are in situ. *Schizaster diabloensis* has been found in shallow-marine and outer shelf to slope deposits in the middle Eocene part of the Llajas Formation, Simi Valley (Squires, 1984). This echinoid has also been found in bathyal deposits of the middle Eocene Aldwell(?) Formation, eastern Olympic Peninsula, Washington (Squires and others, 1992).

The macrofossils found in the Coldwater Sandstone in the study area indicate assignment to the "Tejon Stage" (Fig. 4). *Turritella uvasana uvasana*, *Ficopsis hornii*, *Calorebama volutaeformis*, and *Callista conradiana* are confined to this stage (Givens, 1974; Squires, 1989). The "Tejon Stage" spans a considerable interval of time (from medial medial through late Eocene), but the Coldwater Sandstone in the study area can be assigned to the middle Eocene part of the Tejon Stage" on the basis of the age of the overlying Sespe Formation. Lindsay (1968) found rodent teeth at locality UCMP V-5814 in the lowest part of the Sespe Formation in the vicinity of Hartman Ranch, just north of Highway 33 in the western central part of the study area (Fig. 3), and his work established what is known as the Hartman Ranch Local Fauna. Tortoise and rhinocerotoid fossils were also collected from this fauna. Kelly (1990) assigned the fauna to the upper Uintan or lower Duchesnean North American Land Mammal Stage (equivalent to upper middle Eocene). The age of the Hartman Ranch Local Fauna is very important because it establishes that the Coldwater Sandstone, which interfingers with the Sespe Formation, is no younger than late medial Eocene.

Stock (1938) found a titanothere in the lower part of the Sespe Formation near Hartman Ranch. Kelley (1990) referred to this locality, which is stratigraphically above the Hartman Ranch Local Fauna, as the Sespe Creek Local Fauna and assigned it to the Duchesnean Stage (equivalent to uppermost middle Eocene).

The bivalve *Glyptoactis (Claibornicardia) sandiegoensis* was reported previously to range from the "Capay Stage" to the "Domengine Stage" (Squires, 1987), and the spatangoid echinoid *Schizaster diabloensis* was reported previously to range from the upper Paleocene through the "Domengine Stage" (Squires, 1984). The geologic range of both of these species can now be extended into the "Tejon Stage" on the basis of their presence in the Coldwater Sandstone in the study area.

TAXONOMIC COMMENTS

The genus name for the bivalve *"Crassatella" collina* is enclosed in quotation marks because assignment to genus *Crassatella* is tentative pending detailed morphologic work on the internal shell structure of this bivalve.

Recently, Moore (1992) provided a much-needed synonymy of the bivalve *Venericardia (Pacificor) clarki clarki*, which has been known by seven other names in the literature on Eocene macrofossils of the Pacific coast of North America. This bivalve is known from the Tolstoi Formation in the Pavlof Bay region of the Alaskan Peninsula (Marincovich, 1988); the Cowlitz Formation near Vader in southwestern Washington (Weaver and Palmer, 1922; Weaver, 1942); the lower Coaledo Formation at Cape Arago in southwestern Oregon (Turner, 1938); and the undifferentiated Sacate-Gaviota formation in Nojoqui Creek and upper Gaviota Formation east of Gaviota Pass in southern California (Weaver and Kleinpell, 1963, as *V. lisa*). *Venericardia (Pacificor) clarki clarki* was reported previously as only possibly present in the Coldwater Sandstone of Ventura County (Verastegui, 1953, as *V. weaveri*?; Givens, 1974, as cf. *V. hornii* s.s.). This present report is the first to confirm the occurrence of *Venericardia (Pacificor) clarki clarki* from the Coldwater Sandstone, Ventura County.

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Plate 1. Upper Sespe Creek upper Matilija Sandstone and Cozy Dell Shale macrofossils. Figures 1-4, gastropods; 5-9, bivalves; 10, spiny lobster; 11-12, crabs; 13-14, starfish; 15-16, brittle star.

Upper Matilija Sandstone macrofossils

1. *Turritella uvasana uvasana* Conrad, 1855, rubber cast, abapertural view, x1.1, height 50 mm, width 22 mm, LACMIP hypotype 11626, LACMIP loc. 24260.

2. *Calyptraea diegoana* (Conrad, 1855), internal mold, side view, x2.7, height 5.5 mm, width 14 mm, LACMIP hypotype 11627, LACMIP loc. 24260.

3. *Caloreabama inornata* (Dickerson, 1915), apertural view, x1.7, height 24.1 mm, width 15.2 mm, LACMIP hypotype 11628, LACMIP loc. 24260.

4. *Architectonica* (*Architectonica*) *hornii* Gabb, 1864, rubber cast, dorsal view, x4.2, diameter 7 mm, LACMIP hypotype 11629, LACMIP loc. 23688.

5. *Brachidontes* (*Brachidontes*) *cowlitzensis* (Weaver and Palmer, 1922), rubber cast, left valve, x2.3, length 10 mm, height 18 mm, LACMIP hypotype 11630, LACMIP loc. 24260.

6. *Acanthocardia* (*Shedocardia*) *brewerii* (Gabb, 1864), rubber cast, x1.9, left valve, length 18 mm, height 20 mm, LACMIP hypotype 11631, LACMIP loc. 23688.

7. *Tellina lebecki* Anderson and Hanna, 1925, rubber cast, x2.1, right valve, length 23 mm, height 11 mm, LACMIP hypotype 11632, LACMIP loc. 23688.

Cozy Dell Shale macrofossils (excluding the Circle B sandstone member):

8. *Propeamusium interradiatum* (Gabb, 1869), internal mold, x2.6, left? valve, length 12 mm, height 12.5 mm, LACMIP hypotype 11633, LACMIP loc. 23686.

9. *Delectopecten* sp. indet., internal mold, left? valve, x4, length 9.5 mm, height 7 mm, LACMIP hypotype 11634, LACMIP loc. 23690.

10. Palinurid?, internal mold of abdomen, x2.4, length 18 mm, width 9 mm, LACMIP hypotype 11635, LACMIP loc. 23712.

11. *Raninoides washburnei*? Rathbun, 1926, internal mold of carapace, x1.5, length 31 mm, width 20 mm, LACMIP hypotype 11636, LACMIP loc. 10571.

12. *Glyphithyreus weaveri* (Rathbun, 1926), internal mold of carapace, x2.3, length 12 mm, width 15 mm, LACMIP hypotype 11637, LACMIP loc. 1057.

13. *Astropecten matilijaensis* Durham and Roberts, 1948, mold, aboral view, x1, maximum diameter 75 mm, LACMIP hypotype 11638, LACMIP loc. 7223.

14. *Henricia* (?) *venturana* Durham and Roberts, 1948, rubber cast, oral surface, x1.7, disk diameter 10 mm, LACMIP holotype 4866A [=CIT holotype 4866A], LACMIP loc. 7223.

15-16. Ophiuroid, LACMIP loc. 10571, molds; (15) aboral surface, x1.3, disk diameter 10.5 mm, LACMIP hypotype 11639; (16) oral surface, x1.7, disk diameter 12 mm, LACMIP hypotype 11640.